***For cited:*** *Peker, A. E. (2018). Co-integration Relationship between Climatic Change and Economic Variables: The Case of OECD Countries. Journal of Current Researches on Business and Economics, 8 (2), 135-148.*

Crossref *doi: 10.26579/jocrebe-8.2.9* ***Research Article/Araştırma Makalesi***

**Year: 2018**
**Volume: 8**
**Issue: 2**

**Journal of Current Researches on Business and Economics (JoCReBE)**
**ISSN: 2547-9628**

**http://www.jocrebe.com**

# Co-integration Relationship between Climatic Change and Economic Variables: The Case of OECD Countries

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**Keywords**
Climatic change, Panel data analysis, OECD countries.

**Abstract**
Human life was established on the various balances. The most important one among these balances is accepted as natural balance. In the medium of destructive competition, The fact that countries have made great destructions in the environment for being able to reach high growth figures has been more clearly understood with climatic changes that have been experienced. Together with revealing the scary scenarios, the need for scientific studies, where the effects of climatic change are dealt with, much more increases every passing days for countries to intervene with this course and form sustainable growth policies. Providing safely access to environmental sustainability, water, energy, and the other services plays key role in -achieving Millennium Development Goals (MDG) These goals consist of 8 goals representing a global commitment about providing a rapid development in key development areas. In this context, in this study, the relationship with macroeconomic variables of greenhouse gas emissions was dealt with panel data analysis by using annual data of the period 1971-2016 for 23 IECD countries. In the first stage, horizontal cross section dependence test was made for the data. As a result of this test made, it was seen that there was horizontal cross section dependence between countries. CADF and CIPS panel unit root tests, among second generation unit root tests, taking this case into consideration, were used, and it was seen that the series were not stationary at the level values. The presence of co-integration relationship between the series was examined by means of Westerlund Durbin Hausman (2008) Test, and it was identified that there was a co-integration relationship between series. In the last stage, long term co-integration coefficients were predicted by CCE method, developed by Pesaran (2006b). In the study, it was identified that there were variables at the different statistical levels that affects climatic change for all countries subjected to analysis, However, for all countries, it is accepted that energy consumption is an important determinant without exception as the most important output of the study.

**Article History**
Received
19 Sep, 2018
Accepted
11 Nov, 2018

## 1. Introduction

Beginning from human beings get on the stage of history, it is seen that they affect the environment. In the process from the first ages to industrial revolution, climatic changes arise from natural reasons. However, it is seen that people have considerably high contribution to the reasons for climatic changes forming together with industrial revolution. In case that human beings cannot perform

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what they have to do about disturbance of natural balance, it was dogmatized by climatologist that climatic changes would be experienced due to global warming, and scary scenarios were revealed. Increase of greenhouse gases in atmosphere due to human reasons, increase in particles in air, and depletion in ozone layer caused temperature increase in global scale (Çelik et al, 2008:3).

Global warming is expressed as the increase of mean surface temperature of the world and change in its climatic structure due to the fact that CO2 (carbon dioxide), CH4 (methane), N2O (dinitrogen monoxide), O3 (ozone), CFCs (chlorofluorocarbon) and H2O (water vapor) strengthen natural greenhouse effect as a result of economic activities of people. The increase in greenhouse gas emissions, especially beginning from 1800s, i.e. in the time passing from industrial revolution to these days, is clearly seen ( Dellal, 2008: 103). While global warming is defined as continuously increase in the temperature of the earth, depending on global warming, the changes variations in climatic variables such as drought, rainfall, humidity, and air motion are accepted as climatic change (Çepel, 2003: 125)

The main energy resource used in the world consist of fossil fuels. 84% of energy used by the developed countries and 75% of the energy used by the developed countries are obtained from fossil fuels. It is seen that energy sector comes to forefront in the formation of greenhouse gas emission. Intensively consumption of fossil fuels importantly affects new millennium and exposes it with the problem of climatic change. In order to accelerate the developments of the countries, in Millennium Development Goals globally accepted, environmental sustainability is accepted as one of the main eight goals.

The history of climatic change is chronologically summarized as follows:

**Table 1.** Chronology of the Process

| Year | $CO_2$ density* | Olay |
|---|---|---|
| 1979 | 336.78 | First World Climate Conference |
| 1988 | 351.56 | Intergovernmental Panel of l Climatic Change (IPCC) was established. |
| 1990 | 354.35 | Second World Climate Conference |
| 1991 | 355.57 | First Assessment Report (FAR) by IPCC: Starting of international negotiations. |
| 1992 | 356.38 | United Nations Climatic Changes Framework Convention (UNCCF) was opened for signature. |
| 1994 | 358.82 | UNCCF came into force on March 21, 1994. |
| 1995 | 360.80 | Second Assessment Report (SAR) by IPCC |
| 1997 | 363.71 | . Kyoto Protocol was accepted and opened for signature. Annex -1 That Countries transmit First National Report to secretariat |
| 2000 | 369.52 | Study of Specific Competency Committee on Climatic Change and Preparation Suggestion of Action Plan for 8th five year development plan of Turkey |
| 2001 | 371.13 | *Third Assessment Report (TAR) was published by IPCC.* |
| 2004 | 377.49 | *Turkey became a part of United Nation Climatic Change Framework Convention.* |
| 2005 | 379.8 | *Kyoto Protocol came into action.* |
| 2007 | 383.76 | *Fourth Assessment Report (AR4) was published by IPCC. Bali Action Plan in COP13 for post-2012.*<br>*That Turkey transmit First National Report to Secretariat* |
| 2009 | 387.37 | *Copenhagen Consensus was issued in COP 15.*<br>*Turkey became a part of Kyoto Protocol*<br>*Climatic Change Strategy 2010-2020 was published..*<br>*İDEP Project started* |
| 2010 | 389.85 | *140 Countries reported their commitments in the framework of Copenhagen Consensus.*<br>*COP16 Cancun Agreement*<br>*The hottest year in Turkey* |
| 2011 | 391.63 | *İDEP project was completed.*<br>*COP17 Durban Platform , Termination of Agreement by 2015.* |
| 2012 | 393.82 | *COP18 Doha, Elongation of 2nd Obligation period of Kyoto Protocol by 2020 Excessive becoming smaller in glacier of North Pole in respect of summer end.*<br>*Excessive melting in surface layers of Greenland glacier*<br>*The hottest third year in Turkey* |
| 2013 | May:400 | *COP19 Warsaw in November Month* |

Those written in bold letters are related to Turkey. Density was given as part per million (ppm).
Resource: Association of protecting consumer and climate, assessment report for climatic change action plan

In the recent years, in the medium of destructive competition, it has been more clearly understood that countries have made great destructions in the environment for being able to reach high growth figures with climatic changes that have been experienced. Together with revealing the scary scenarios, the need for scientific studies, where the effects of climatic change are dealt with, much more increases every passing days for counties to intervene with this course and

form sustainable growth policies. Providing safely access to environmental sustainability, water, energy, and the other service plays key role in achieving Millennium Development Goals (MDG) These goals consist of 8 goals representing a global commitment about providing a rapid development in key development areas. In this context, in this study, the relationship with macroeconomic variables of greenhouse gas emissions was dealt with panel data analysis by using annual data of the period 1971-2016 for 23 OECD countries.

In the first stage, horizontal cross section dependence test was made for the data. As a result of this test made, it was seen that there was horizontal cross section dependence between countries. CADF and CIPS panel unit root tests, among second generation unit root tests, taking this case into consideration were used, and it was seen that the series were not stationary at the level values. The presence of co-integration relationship between the series was examined by means of Westerlund Durbin Hausman (2008) Test, and it was identified that there was a co-integration relationship between series. In the last stage, long term co-integration coefficients were predicted by CCE method, developed by Pesaran (2006b). In the study, it was identified that there were variables at the different statistical levels that affects climatic change for all countries subjected to analysis, However, for all countries, it is accepted that energy consumption is an important determinant without exception as the most important output of the study.

## 2. Climatic Economy

Depending on the increase of global population, due to human activities such as the increase of consumption, change of consumption habits, increase of fossil fuel consumption, and deforestation, greenhouse gas accumulation in atmosphere increased and led climatic changes to be experienced. This change caused atmosphere and ocean to be warmed, global water cycle to change, glacier to melt, sea level to rise, rainfall regimes to change, and the intensity and frequency of natural disasters such as drought, flood, and hurricane. to increase. The main reason for global warming results from that besides the presence of greenhouse gas in atmosphere, the density of greenhouse gas is much more than normal. That this increase is fast leads natural greenhouse effect to accelerate and temperature to increase in the layers near earth (Bayraç and Doğan, 2016:26).

The rise of mean temperatures and fluctuations forming in rainfall regime have shown the first effects of climatic changes. The variation occurring in these variables led droughts to increase and change the intensity and frequency of natural disasters. So, it is seen that 87%of natural disasters experienced in the period 1990-2012 result from climate (Munich RE, 2013: 52-53). It is estimated that economic loss experienced due to natural disasters is $ 85 billion and that this figure will rise to $ 1 trillion in 2050 (Hallegatte et al, 2013: 802).

That the existing sectors taking place in economies are affected from climatic changes realizes in the different levels. While some sectors are directly affected from this state, some sectors are indirectly affected (Lecocq and Shazili, 2007:41). Among those most affected from climatic changes all over the world, agricultural sector takes place. When considered that the most important element in

actualization of agricultural production is climate, this case is an expected phenomenon. The temperature, rainfall, and variations in the amount of CO2 in atmosphere directly affect agricultural production and agricultural productivity. The increase in temperatures and decreases in the amount of rainfall leads agricultural production to fall, and this case causes also the prices of agricultural product to fall and increase the phenomenon inflation in agricultural products (Basoglu, 2014:181-183). Hence, this case leads food security to be questioned in country economies, providing price stability to become difficult, and economic policies by central bank to be questioned (Basoglu, 2014:181-183). Tourism sector is also one of the activity areas sensitive to climatic changes. Environmental conditions are closely related to tourism. Whatever the developedness level of country economies are, it is seen that tourism incomes are determinative. In terms of transformation the addition of balance of payments into positive, increase of employment possibilities of the country, and protection of natural beauties of the country, it should not be forgotten that climate has an important place for the sector.

Fluctuation occurring in climatic changes directly or indirectly affects energy supply and demand. For example, since hydroelectric generation completely depends on water level, it is directly affected from climatic changes. The decrease occurring in rainfall regimes leads hydroelectric production to seriously decrease. In the countries like Turkey, which is foreign –dependent in energy consumption, this case leads current account balance to disturb. Rapid increase of rainfall regimes will lead energy plant to be damaged physically. While solar energy is not directly affected from climatic change, since nuclear energy centrals use high amounts of water to cool down, they are directly affected. When all of these factors are taken into consideration, the variation of energy supply and demand will be effective on energy prices.

One of the sectors, where climatic change is effective, is also health sector. Over rise of temperature and variations occurring in humidity rate are indirectly affect human health. That people are negatively affected leads productivity to decrease in many sectors, where the people are employed, and employment capacity to change. That many sectors are affected in economy makes indirect contribution to the growth figures to be affected. Many elements such as the rise of costs, efficiency of production factors in the sector, and change of consumer habits due to climatic change create some points revealing the sensitivity of this issue. In addition, the investments countries make to eliminate the negative effects of climatic change will also lead to the formation of alternative costs in country economies. In this concept, in terms of emphasizing the importance of the issue and making action plans oriented to the issue, it is considered that this study will shed light on the literature.

## 3. Dataset and Econometric Model

### 3.1. Dataset

In the scope of the study, in order to determine the relationship between climatic change and economic variables, the data of 23 OECD countries based on the period 1971-2006 were subjected to analysis. Since the continuity of the data are taken

into consideration in determining the number of country, the countries that are OECD member but whose data are missing are excluded from the analysis. All variables used are compiled from OECD (World Bank, 2018) and some data are included in the analysis, making their logarithmic transformation. In the stage of economic application, Eviews 8, Gauss 10, STATA 11.0 software was utilized. The abbreviations and explanations belonging to the variables used during applications were presented in Table 2.

Table 2: Definitions of Variables

| Variables | Description of Variables |
|---|---|
| LCO | CO2 emissions (metric tons per capita) |
| LEC | Electric power consumption (kWh per capita) |
| LEN | Energy use (kg of oil equivalent per capita) |
| LGDP | GDP per capita (constant 2010 US$) |
| OPEC | Trade Openness ( (Export + Import )/ GDP ) |

In the analysis, OPEC series is taken as percentage and LCO, LGDP, LEL and LEN series are included in the model after their level values and logarithms. In the study, three mathematical models are analyzed. The equations of mathematical models in this study are given as follows:

**Model 1:** $LCO = \beta_0 + \beta_1 LGDP_{it} + E_{it}$ (1)

**Model 2:** $LCO = \beta_0 + \beta_1 LEC_{it} + \beta_2 LEN_{it} + E_{it}$ (2)

**Model 3:** $LCO = \beta_0 + \beta_1 OPEC_{it} + E_{it}$ (3)

In order to be able to reach long term parametric coefficients, for three models, the presence of horizontal cross section dependence between the countries taking place in the panel and whether or not panel has a homogenous structure must be studied. In this direction, before identifying co-integration relationship, the presence of horizontal cross section dependence via deviation-adjusted CD test by Pesaran et al. (2008) was studied, and then it was controlled by means of Pesaran (2008) Test. The findings obtained regarding these two tests have a great importance in terms of identifying unit root method and co-integration test to be used. In case of presence of horizontal cross section dependence, using the second generation methods will increase the reliability of the results to be obtained. In this study, the stationarity level of series was studied by means of Pesaran (2007) CADF unit root test considering horizontal cross section dependence and, following this, the presence of co-integration relationship was controlled by Westerlund (2008) Durbin Hausman co-integration method. . Lastly, in long term equation, the coefficients the variables have were calculated by means of Pesaran (2006) Common Correlation Estimator (CCE) method for both all panel and each country.

### 3.2. Econometric Model

In case of that there is horizontal cross section dependence between series, significant deviations occur in the results of analysis (Breusch and Pagan, 1980; Pesaran, 2004). In view of this, while analyzing, it is necessary to test the presence of horizontal cross section dependence in the series. The method used for testing horizontal cross section dependence in panel datasets are Pesaran et al (2004)

CDLM test, Breusch-Pagan (1980) CDLM1 test and Pesaran et al (2004) CDLM2 tests. In the first stage of empirical analysis, the presence of horizontal section dependence between horizontal cross section units was studied. In order to be able to apply the CDLM1 and CDLM2 tests of 46 years (T) covering the period 1971-2016 and 23 OECD countries, the realization of the necessary conditions were provided. .In CDLM1 and CDLM2 tests, under the assumption that every country can be distinctly affected from individual time, estimation is made.

Hypotheses of the Test :

H_0: There is no horizontal cross section dependence

H_1: There is horizontal cross section dependence .

In Table 3, horizontal cross section dependence to be estimated in the scope of this study.

**Table 3.** Results of Horizontal Cross Section Dependence

| **TESTLER** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| CD LM1 (Breusch, Pagan 1980) | 2834,429<br>(0,000) | 2090,476<br>(0,0000) | 2582,240<br>(0,0000) |
| CD LM2 (Pesaran 2004 CDLM) | 114,759<br>(0,0000) | 81,686<br>(0,0000) | 109,547<br>(0,0000) |
| CD LM (Pesaran 2004 CD) | 37,803<br>(0,0000) | 25,108<br>(0.0000) | 19,579<br>(0,0000) |

When probability value to be obtained as a result of the test is less than 0.05, at the significance level of 5%, H0 hypothesis is rejected and it is decided that there is a panel cross section dependence between the units forming the panel (Pesaran et al., 2008). In this case, for the countries forming panel, it was identified that there was horizontal section dependence in all models. The shocks coming to one of the countries also affect the other countries. Therefore, while decision makers in the countries determine economic policies, they must also consider the policies the other countries apply and the shocks affecting the variables LEC, LEN, LGDP and OPEC of these countries. While the presence of co-integration relationship and co-integration equation between series are estimated, it is necessary to use test methods considering horizontal cross section dependence.

After determining the presence of horizontal cross section dependence between panels, in the following stage, stationarity features were studied by using CADF test. This method developed by Pesaran (2007) is one of second generation methods testing whether or not series includes unit root in the presence of horizontal cross section dependence. This method tests that series includes unit root in null hypothesis, in other word, is not stationary, while in alternative hypothesis, tests the stationarity of the series. For being able to decide, stationarity degree of the series, the value of CADF must be compared with Pesaran (2007) critical table value. That CADF statistics is higher than Pesaran (2007) critical table value, it means that this hypothesis will be rejected and that series is stationary. The results of CADF unit root test belonging to the variables used in this study take place in Table 4.

**Table 4.** The results of CADF and CIPS unit root test

| Country | lco | Δlco | lgdp | Δlgdp | len | Δlen | lel | Δlel | opec | Δopec |
|---|---|---|---|---|---|---|---|---|---|---|
| Australia | -3,173 | -5,075 | -1,600 | -2,155 | -3,141 | -3,437 | -1,109 | -5,320 | -3.216 | -8.330 |
| Austria | -2,459 | -7,224 | -2,669 | -4,123 | -2,741 | -3,969 | 0,172 | -3,687 | -2.547 | -3.938 |
| Belgium | -2,259 | -4,326 | -3,400 | -4,481 | -2,664 | -3,576 | -2,805 | -3,690 | -2.358 | -4.499 |
| Canada | -2,369 | -7,610 | -2,350 | -4,253 | -4,831 | -3,054 | -1,741 | -3,053 | -1.292 | -2.925 |
| Denmark | -1,046 | -3,865 | -2,716 | -4,733 | -4,964 | -7,509 | -0,467 | -4,367 | -2.312 | -4.565 |
| Finland | -4,061 | -7,527 | -2,233 | -3,771 | -5,032 | -7,632 | -1,651 | -2,877 | -1.392 | -3.479 |
| France | -1,364 | -5,679 | -2,464 | -3,895 | -4,900 | -7,712 | -1,111 | -5,732 | -2.004 | -4.726 |
| Germany | -2,548 | -3,352 | -2,587 | -3,572 | -4,912 | -7,729 | -2,913 | -2,144 | -2.300 | -5.491 |
| Greece | -2,909 | -5,923 | -1,140 | -4,576 | -4,928 | -7,683 | -1,932 | -7,080 | -0.937 | -4.333 |
| Ireland | -2,787 | -4,733 | -1,530 | -2,852 | -4,971 | -7,597 | -2,044 | -3,716 | -3.606 | -3.763 |
| Italy | -0,299 | -4,830 | -0,430 | -3,299 | -4,940 | -7,742 | -1,569 | -3,929 | -2.465 | -5.034 |
| Japan | -0,734 | -3,965 | -0,894 | -2,877 | -5,421 | -7,769 | -1,491 | -2,577 | -3.074 | -4.326 |
| Korea, Rep. | -1,472 | -5,120 | -0,918 | -3,644 | -5,048 | -7,876 | -2,088 | -5,516 | -4.462 | -6.625 |
| Mexico | -3,107 | -3,762 | -2,869 | -5,002 | -4,800 | -8,918 | -2,096 | -5,728 | -3.238 | -5.137 |
| Netherlands | -2,890 | -4,729 | -1,551 | -2,937 | -5,173 | -8,724 | -0,629 | -2,574 | -3.229 | -4.912 |
| New Zealand | -1,047 | -4,314 | -1,313 | -3,652 | -4,720 | -8,878 | 0,075 | -4,238 | -4.400 | -5.723 |
| Norway | -1,939 | -3,894 | -1,364 | -3,557 | -4,524 | -8,075 | -1,918 | -6,547 | -2.249 | -4.746 |
| Portugal | -1,511 | -4,444 | -2,629 | -5,565 | -4,577 | -8,000 | -2,734 | -5,893 | -2.902 | -5.324 |
| Spain | -3,301 | -4,048 | -3,176 | -3,350 | -5,130 | -7,441 | -1,228 | -3,030 | -3.659 | -4.760 |
| Sweden | -2,301 | -5,111 | -1,107 | -4,450 | -4,888 | -8,134 | -1,757 | -3,205 | -2.550 | -4.802 |
| Turkey | -0,585 | -4,817 | -0,868 | -4,488 | -1,493 | -3,307 | -1,820 | -4,629 | -3.241 | -4.613 |
| U. Kingdom | -1,260 | -5,520 | -3,943 | -4,913 | -3,040 | -3,457 | -3,061 | -3,329 | -3.429 | -3.365 |
| United States | -3,809 | -6,117 | -4,219 | -4,529 | -3,171 | -3,442 | -2,990 | -6,979 | -2.407 | -3.687 |
| CIPS STAT | -2,142 | -5,042 | -2,085 | -3,942 | -4,348 | -6,594 | -1,692 | -4,353 | -2.751 | -4.744 |

Note: *:1% , **:5% ***:10% express significance level. Critical values of CIPS test statistics are 2.72, -2.49 ve -2.37 for 1%, 5%, and 10%, respectively. These critical values are drawn from Table 5(b) in Pesaran (2009: 5) study. The critical values of CADF test statistics are – 4.74, - 3.83, and -3.41 for 1%, 5%, and 10%, respectively. These critical values are drawn from Table 5(b) in Pesaran (2009: 11) study.

It was identified that the CADF test statistics results of country groups forming panel, calculated as "with fixed term" and "with trend" included unit root at level values for all variables for all variables. After identification of stationarity levels of the series with unit root methods, in the following stage, the presence of long term relationship between the relevant variables must be studied. Although there are many co-integration test developed for this aim, many of these methods can make this analysis for the variables having stationarity at the same level. Westerlund (2008) developed a method giving significant results under horizontal cross section dependence in order to use in identifying the presence of long term relationship between the variables that are integrated at the different levels. Westerlund (2008) Durbin- Hausman co-integration test, on condition that dependable variable is stationary in the first degree, is a method allowing for the stationarity of independent variables from the different levels. In other words, on condition that the variable is I(1), integration degrees of independent variables that will take place in long term equation may be I(0) or I(1) (Westerlund 2008, 205). There are two tests suggested by Westerlund. First of these is Durbin Hausman panel test, while the second is Durbin Hausman group test. This test assumes that autoregressive parameter does not change between the sectors. Test moves from Fisher equation (Westerlund, 2008: 196-199) and the hypotheses of Durbin Hausman panel test, the first test, are as follows:

H0 : = 0

H1 : < 0

**Table 5.** The Results of Westerlund (2008) Durbin-Hausman Co-integration Test

| **Testler** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| Durbin H grup istatistiği | -2,577 | -2,513 | -1,913 |
| P değeri | 0,005 | 0,006 | 0,028 |
| Durbin H Panel istatistiği | -3,086 | -3,078 | -3,206 |
| P değeri | 0,001 | 0,001 | 0,001 |

In order to test whether or not there is a co-integration in panel data, Durbin-H Co-integration Test, developed by Westerlund (2008) and considering horizontal cross section dependence and heterogeneity of horizontal cross section slope parameters, was used. One of two tests, suggested by Westerlund (2008) in this framework, is Durbin Hausman Test. This test assumes that autoregressive parameter does not change between sectors and tests H0: "There is no co-integration "null hypothesis. Rejection of null hypothesis indicates that there is co-integration relationship in all panels. Durbin-H group test, the second test, allows for coefficients to differentiate between sectors. Null hypothesis is defined as "There is no co-integration", while alternative hypothesis is defined as "There is co-integration at least in one cross section". The rejection of null hypothesis is the evident that there is co-integration relationship at least in some sectors.

In the analysis of panel dataset of the study, the presence of unit root, horizontal cross section dependence, a heterogeneous structure, and co-integrated structure was identified and, in this stage, long-term co-integration coefficients were estimated by estimation method based on Common Correlated Effects-CCE. Although CCE considers horizontal cross section dependence and allows for scope to change from horizontal cross section to horizontal cross section, it is an estimator, which can individually be used in calculating long term balance values for N > T and N< T (When the dimension "time" is bigger or smaller than the dimension "horizontal cross section", CCE can produce the results that show asymptotic and normal distribution) and each horizontal cross section (Pesaran, 2006b: 967; Pesaran ve Yamagata, 2008: 50). In addition, Pesaran (2006b: 967, 998), suggests to select CCEP-Common Correlated Effect Pooled estimators that while T and N are small and select CCEMG estimator, while they are bigger.

In this stage of the study, with moving from that compliance degree of series is I(1), co-integration study was carried. In the selection of co-integration tests, there are two tests suggested by Westerlund, which consider horizontal cross section dependence and enabling some of explanatory variables to be I(0). The first of these is Durbin Hausman panel test, while the second is Durbin Hausman group test. This test assumes that autoregressive parameters do not change between sectors. It moves from Test Fisher equation (Westerlund, 2008: 196-199) and hypotheses of Durbin Hausman panel test, the first test, are as follows:

H0 : = 0

HA : < 0

If null hypothesis is rejected, the result that there is co-integration relationship for all panel. Durbin-Hausman group test, the second test, allows for coefficients to differentiate between sectors. The hypotheses of this test are the same as hypotheses in Durbin Hausman panel test. It is reached the conclusion that the in test for groups, there is co-integration relationship at least in some sectors is reached. Test results are presented in Table 6.

As a result of the analysis made, it was reached the conclusion that energy consumption per capita were statistically significant and positive at the different levels in all countries. This conclusion is complied with the studies of Acaravci and Ozturk (2010), Bella et al., (2010), and Marrero (2010) taking place in the literature. GDP we take as economic growth turned out significant in the countries other than Canada, Denmark, Greece, Mexico, Turkey, and USA. It was seen that the relationship between economic growth and carbon emission was significant and negative in Finland, Ireland, Norway, Holland, and Spain. These results overlap with those of Jaunky (2011: 1238). The effect of economic growth on carbon emission is positive and statistically significant. In Austria, Belgium, France, Italy, Korea, New Zeeland, Portugal, Sweden, and United Kingdom, it was concluded that there was a positive and significant relationship between two variables. This conclusion obtained is in compliance with the studies by Jaunky, (2011); Adom et al. (2012); Ahmed and Long (2012); and Öztürk and Acaravci (2012).

**Table 6:** CCE estimation results

| | **LEL** | | **LEN** | | **LGDP** | | **OPEC** | |
|---|---|---|---|---|---|---|---|---|
| Australia | 0,1055 | 0,58 | 0,785 | 4,59* | 0,644 | 2,67* | 0,060 | 1,10 |
| Austria | -0,309 | -0,67 | 1,056 | 3,29* | -0,072 | -0,17 | 0,416 | 2,39* |
| Belgium | 0,803 | 2,97* | 0,361 | 1,42*** | 1,172 | 2,16** | -1,083 | -5,06* |
| Canada | -0,151 | -1,48*** | 0,732 | 3,95* | 0,152 | 0,91 | 0,151 | 2,34* |
| Denmark | 0,328 | 1,29*** | 1,179 | 6,08* | 0,232 | 0,50 | 0,467 | 1,41*** |
| Finland | -0,438 | -1,57*** | 2,09 | 9,70* | -0,742 | 3,86* | -1,086 | 0,75 |
| France | -0,367 | 0,332 | 0,518 | 1,42*** | 1,403 | 2,30** | -2,208 | -1,14 |
| Germany | -0,192 | -0,38 | 0,680 | 1,39*** | 0,821 | 2,70* | 0,009 | 0,05 |
| Greece | 0,016 | 0,10 | 0,935 | 7,91* | -0,109 | -1,25 | -0,064 | -1,62*** |
| Ireland | -0,023 | -0,17 | 1,17 | 19,07* | -0,146 | 4,07* | 0,201 | 4,34* |
| Italy | 0,293 | 1,30* | 1,00 | 7,06* | 0,628 | 4,36* | 0,017 | 0,49 |
| Japan | 0,226 | 0,83 | 0,593 | 2,44* | 0,258 | 1,84*** | -0,127 | -3,00* |
| Korea, Rep. | 0,237 | 1,69* | 0,822 | 5,96* | 0,119 | 0,75 | 0,037 | 0,82 |
| Mexico | 0,171 | 1,00 | 0,750 | 6,47* | -0,081 | -1,24 | -0,019 | 0,73 |
| Netherlands | 1,026 | 2,12** | 0,744 | 4,27* | -0,934 | -2,07** | -0,559 | -2,57* |
| N.Zealand | 0,566 | 1,93** | 1,065 | 5,49* | 0,540 | 1,74** | 0,121 | 1,02 |
| Norway | 0,323 | 0,91 | 1,721 | 8,38* | -0,712 | -1,49*** | -0,111 | -1,38*** |
| Portugal | -0,496 | -2,00** | 1,282 | 11,46* | 0,352 | 1,82** | 0,061 | -1,00 |
| Spain | 0,785 | 4,39* | 1,043 | 6,11* | -0,436 | -1,52*** | -0,060 | -0,63 |
| Sweden | -1,121 | -3,05* | 0,682 | 2,83* | 0,726 | 1,49*** | -0,161 | 0,536 |
| Turkey | 0,017 | 0,15 | 1,056 | 7,83* | 0,034 | 0,26 | 0,06 | 1,81*** |
| U.Kingdom | 0,414 | 1,45*** | 0,763 | 3,56* | 0,884 | 3,91*** | 0,127 | 1,90** |
| U.States | 0,091 | 0,69 | 0,835 | 7,78* | 0,044 | 0,31 | -0,92 | -0,92 |

Not: *:1% , **:5%, ***:10% express .stationarity at the significant level If Z statistics values are bigger than 2.32, they are significant at 1% ; if they are bigger than 1.65, they are significant at 5%; and if they are bigger than 1.28, they are significant at 10 %.

It was concluded that the relationship between trade openness, obtained by dividing by GDP a total of export and import, and carbon emission was positive

directional and significant for United Kingdom, Turkey, Canada, Denmark, and Austria. For Belgium, Greece, Japan, and Norway, it was concluded that the relationship between two variables was negative directional and significant. Among the countries, where the relationship between electric power consumption per capita and carbon emission was positive directional and statistically significant, Belgium, Italy, Denmark, Korea, New Zealand, and United Kingdom take place. For Turkey, it is seen that one of two factors affecting carbon emission positively and significantly is energy consumption per capita and the other is trade openness. Especially the increase of energy consumption per capita play role at the determinative level in the increase of carbon emission.

## 4. Conclusion

For the period 1971-2016, at the end of this study aiming at revealing the relationship between carbon emissions and macro variables, it was identified that the main determinative element was energy. That fossil fuels are intensively used as energy resources and economies are focused on energy-intensive sectors take place among the most important reasons for this case. In the recent years, in global competitive environment, for many countries to be able to survive in destructive competitive environment, in reaching sustainable growth targets, it is seen that energy resources are consumed at high levels. It is known that together with the process of climatic change, the target of a sustainable growth is directed to environmental friendly renewable energy resources rather than fossil resources and that many countries have intensively begun to work. However, the result of analysis shows that it is rapidly to complete these works and increase the administering power of international and national policies. In addition, country administrations make their citizens about this issue is an expected other situation for reducing the demands of the energy resources containing fossil fuels. It can be reached the conclusion that the countries, in which the direction of the relationship between GDP per capita and carbon emissions is found negative, has become sensitive to the environmental issue after having economic growth. It must not be forgotten that whatever the developedness level is, among the final growth targets of the countries, high growth figures take place. That they can reach these figures becomes possible with high energy and electricity consumption. In this context, using and developing the new energy resources have a great importance. It should not be forgotten that a sustainable growth will be provided, when only such a situation actualizes.

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E-ISSN:
2547-9628

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